Transition Technologies

Schlumberger

EverCRETE CO_2-resistant cement system

Extend cement barrier lifetime in reservoirs containing CO_2

Aligned with United Nations Sustainable Development Goals: 12—Responsible consumption and production, 13—Climate action.

CO_2 Reduction:
Serves as barrier for CO_2 storage wells or high CO_2-producing formations. Lowers CO_2 footprint during well construction due to significantly reduced usage of Portland cement.

Temperature:
up to 284 degF [140 degC]

Applications

- Carbon capture and storage wells
- Wells in fields that use CO_2 injection for enhanced oil recovery (EOR)
- Primary cementing in CO_2 environments
- Long-term decommissioning objectives for plug and abandonment (P&A) in CO_2 environments

How it improves wells

Because of its intrinsic low permeability, EverCRETE* CO_2-resistant cement system resists cement matrix attack from wet supercritical CO_2 and water saturated with CO_2 conditions. Accelerated reaction kinetics lead to a stabilized matrix within days of exposure to the CO_2 environment, leading to stabilized mechanical properties.

How it works

EverCRETE system blends can be prepared locally using the standard bulk plant. The density can be tailored to well requirements, providing operational flexibility. Unlike other offerings, EverCRETE system is compatible with portland cement. The EverCRETE system can be used as a cement across potential CO_2-producing formations or as the primary barrier in the wellbore for any in situ fluids, with a portland cement-based slurry used as a filler slurry for coverage of remaining casing. It can be prepared and pumped using standard equipment. Additionally, the cement can be engineered with self-healing properties that are reactive to CO_2 exposure.

What it replaces

Portland cement systems are used conventionally for zonal isolation in wells. However, portland cement is thermodynamically unstable in CO_2-rich environments and can degrade rapidly upon exposure to CO_2 in the presence of water. As CO_2-laden water diffuses into the cement matrix, the dissociated acid (H_2CO_3) reacts with the free calcium hydroxide and the calcium silicate hydrate (C-S-H) gel. The reaction products are soluble and migrate out of the cement matrix. Eventually, the compressive strength of the set cement decreases and the permeability and porosity increase, leading to loss of zonal isolation.

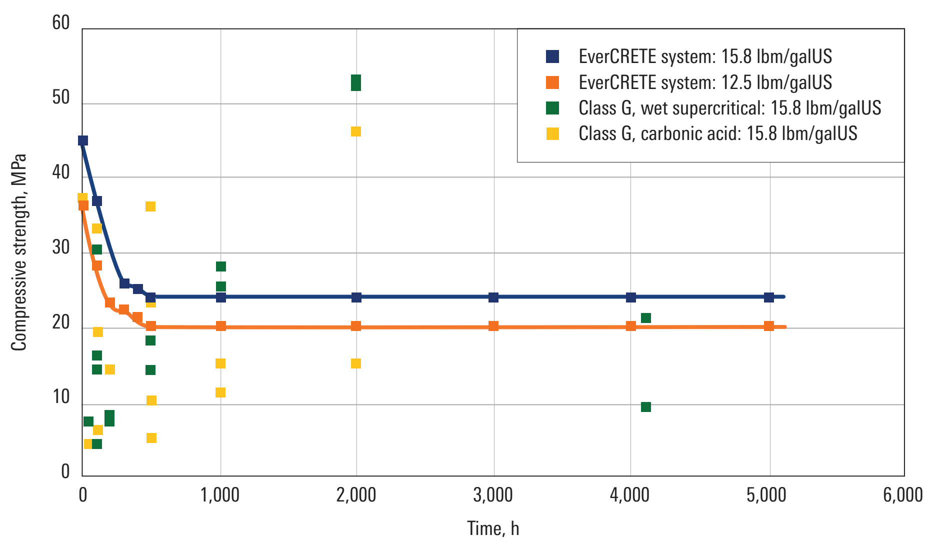
Why it's ideal in any CO_2 environment

Well integrity has been identified as the biggest risk contributing to leakage of CO_2 from underground carbon capture and storage sites. EverCRETE system enables efficient underground storage and keeps greenhouse gases out of the atmosphere.

For wells in fields that use CO_2 injection for EOR or may use it in the future, EverCRETE system reduces the risk of cement sheath degradation and leakage. It can be used to cement new CO_2 injection wells or to plug and abandon injection or production wells at the end of the field life.

In case there is damage to the cement matrix and CO_2 starts to migrate, the self-healing capabilities that can be incorporated in EverCRETE system will repair the crack, reestablishing the integrity of the well and recovering zonal isolation.

EverCRETE system can also be used as a cement across potential CO_2-producing formations or as the primary barrier in the wellbore for in situ fluids after abandonment and permanent decommissioning.



Compressive strength evolution of portland cement and EverCRETE system samples with time in wet supercritical CO_2 fluid and in CO_2 saturated in water at 194 degF [90 degC] under 28 MPa of pressure. After 6 months in CO_2-saturated water, the compressive strength of portland cement is not measurable because most of the samples are highly deteriorated. The stability of the EverCRETE system minimizes the degradation potential of the long-term barrier.

*Mark of Schlumberger
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PRE-OPERATIONAL LOGGING & TESTING PLAN
for the
SAN JUAN BASIN CARBONSAFE PROJECT

Version Number: 1.0
Version Date: 6/6/2022

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1 Facility Information

Facility Name: San Juan Basin CarbonSAFE Facility
SJBCS Well #1 through SJBCS Well #10

Facility Contact: Robert Van Engelenhoven / Vice President Operations & Development
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Farmington, NM 87402
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Location of Wells: The Class VI injection wells are located in San Juan County, New Mexico. Locations of proposed individual wells are listed in Table 1-1.

Table 1-1: List of proposed well locations for the San Juan Basin CarbonSAFE facility.

Well	Location *		
	Latitude	Longitude	Section, Township, Range
SJBCS #1	36.907000°	-108.122500°	Section 08, T 31 N, R 12 W
SJBCS #2	36.869852°	-108.058480°	Section 25, T 31 N, R 12 W
SJBCS #3	36.866630°	-108.100204°	Section 28, T 31 N, R 12 W
SJBCS #4	36.686155°	-108.171202°	Section 35, T 29 N, R 13 W
SJBCS #5	36.677980°	-108.196260°	Section 34, T 29 N, R 13 W
SJBCS #6	36.675999°	-108.236712°	Section 35, T 29 N, R 13 W
SJBCS #7	36.667311°	-108.145182°	Section 32, T 29 N, R 13 W
SJBCS #8	36.661280°	-108.205069°	Section 15, T 28 N, R 13 W
SJBCS #9	36.661166°	-108.176082°	Section 13, T 28 N, R 13 W
SJBCS #10	36.647946°	-108.186248°	Section 23, T 28 N, R 13 W
Characterization Well	36.899793°	-108.061189°	Section 14, T 31 N, R 12 W
SJBCS Monitoring Well #1	TBD	TBD	
* The coordinate system for the San Juan CarbonSAFE III project is MENTOR:NM-W:NAD27 New Mexico State Planes, Western Zone, US Foot"			

2 Introduction

The proposed pre-operational logging and testing program (program) will be implemented to obtain an analysis of the chemical and physical characteristics of the injection zone and confining zone(s) that meets the testing requirements of 40 CFR 146.87 and well construction requirements of 40 CFR 146.86. The program will include a combination of logging, coring, fluid sampling, and other activities during the drilling and construction of the CO_2 injection well, and the characterization well. The program is designed to determine or verify the depth, thickness, mineralogy, lithology, porosity, permeability, and geomechanical characteristics of the Saltwash, Bluff and Entrada formations (CO_2 injection zone), the overlying Brushy Basin, Summerville and Chinle group (confining zone), and other relevant geologic formations. In addition, formation fluid characteristics will be obtained from the targeted injection formation to establish baseline data against which future measurements may be compared after the start of injection operations.

The results of the logging and testing activities will be documented in a report and submitted to the U.S. Environmental Protection Agency (EPA) after the well drilling and testing activities have been completed but before the start of CO_2 injection operations. Before drilling the injection wells, a characterization well will be drilled at the injection well location to collect pre-operational characterization and testing data for the injection wells.

The permittee will submit to the Director for review all procedures for logging, sampling, and testing required by 40 CFR 146.87 no later than 30 days prior to performing the first test, along with the schedule for such testing. The permittee shall submit any changes to the schedule 30 days prior to the next scheduled test. Testing shall not proceed without the Director's approval of the schedule.

3 Proposed Pre-Operational Logging Program

Open-borehole and cased-hole logs will be run to obtain densely spaced, in situ, structural, stratigraphic, physical, chemical, and geomechanical information for the Entrada, Bluff, Dakota, Summerville and other key formations. The proposed pre-operational logging program is detailed in Table 3-1.

Table 3-1: Proposed logging program

Well Logging	Logging Program	Purpose/Comments	Depth Intervals
Surface Casing			
Measurements While Drilling	Near Bit Gamma Ray (GR) and Annular Pressure while drilling (APWD)	• Avoid drilling problems, such as pack off, formation fracture and hole cleaning issues.	1,500'-0'
Open Hole	Triple combo (Resistivity, Density, Neutron, Gamma Ray [GR], Caliper[CALI], and Spontaneous Potential [SP])	• Characterize basic geology (lithology, mineralogy, porosity)	1,500'-0'
Cased Hole	Cement bond log [CBL/VDL/CCL], Radial (Azimuthal) cement evaluation, Flexural wave imaging, temperature	• Evaluate cement integrity	1,500'-0'
Intermediate Casing			
Measurements While Drilling	Near Bit Gamma Ray (Gr) and Annular Pressure while drilling (APWD)	• Avoid drilling problems, such as pack off, formation fracture and hole cleaning issues.	5,500'-1,500'
Open Hole	Triple combo (Resistivity, Density, Neutron, Gamma Ray, Caliper, SP), Dipole sonic, Formation Imager - FMI	• Characterize basic geology (lithology, mineralogy, porosity) • Evaluate borehole condition prior to cementing	5,500'-1,500'
Cased Hole	Cement bond log [CBL/VDL/CCL], Radial (Azimuthal) cement evaluation, Flexural wave imaging, temperature	• Evaluate cement integrity	5,500'-1,500'

Production Casing			
Measurements While Drilling	Near Bit Gamma Ray (Gr) and Annular Pressure while drilling (APWD)	• Avoid drilling problems, such as pack off, formation fracture and hole cleaning issues.	8,800'-5,500'
Open Hole	Triple combo (Resistivity, Density, Neutron, Gamma Ray [GR], caliper, and spontaneous potential [SP])	• Characterize basic geology (lithology, mineralogy, porosity) • Evaluate borehole condition prior to cementing	8,800'-5,500'
	Dipole Sonic, including long recording times to see reflections from fractures and faults, Formation Imager - FMI, Litho Scanner with Spectral Gamma Ray, Magnetic Resonance Scanner, Dielectric Scanner, Formation Fluid Samples of porous zones, Sidewall Coring		8,800'-5,500'
Cased Hole	Cement bond log [CBL/VDL/CCL], Radial (Azimuthal) cement evaluation, Flexural wave imaging, temperature, Cased Hole Nuclear Spectroscopy, Casing Inspection Log, Zero Offset Vertical Seismic Profile	• Evaluate cement integrity	8,800'-5,000'

4 Proposed Pre-Operational Coring Program

The entire depth interval, from 7,410’ to 8,346’ (Total: 936 ft), is required for the coring process. Sections of whole core will be collected from:

1) the lower 10’ at the base of the Dakota Sandstone. and into the top of the Morrison (Brushy Basin Mbr. @ 7420’), this core will look at the geomechanical properties of the seal between the lower reservoir units (Salt Wash, Bluff, and Entrada) and the Dakota Sandstone;

2) the lower 90’ of the Brushy Basin Mbr. into the upper 30’ of the Salt Wash Mbr. of the Morrison Fm. This core will information regarding both the transition between these two members of the Morrison and the lower Brushy Basin’s sealing characteristics;

3) the lower 105’ of the Salt Wash Mbr. of the Morrison Fm. through the upper 30’ of the Carmel Fm. (top @ 8316’). This core will include all the Bluff Ss. (top @ 7971’), the Summerville Fm. (top @ 8098’), the Todilto Ls. (top @ 8180’), and the Entrada Ss. (top @ 8200’). This core will contain all or part of our identified CO_2 reservoirs (Salt Wash, Bluff and Entrada) and will provide an opportunity to measure reservoir properties as well as determine the impact of depositional environment, burial diagenesis, compaction, and primary mineralogy on reservoir heterogeneity (especially the upper half of the Entrada which has the best porosity regionally and compare it to the tighter, less permeable lower Entrada).

The proposed coring program is detailed in Table 4-1.

Table 4-1: Proposed coring program

Item	Goal	Depth Intervals
Coring interval #1	Look if there is enough of a seal between the lower reservoir units (Salt Wash, Bluff, and Entrada) and the Dakota Ss. (a gas producer in the area).	7,410'-7,530'
Coring interval #2	Look at both the transition between these two members of the Morrison and the lower Brushy Basin's sealing characteristics.	7,621'-7,691'
Coring interval #3	Collect cores in Salt Wash and Bluff formation, cap rock, and underlying formation. Also Collect cores in Entrada formation, cap rock, and underlying formation.	7,866'-8,346'

5 Proposed Pre-Operational Fluid Sampling Program

Fluid temperature, pH, conductivity, reservoir pressure and static fluid level of the injection zone will be measured prior to injection. The proposed fluid sampling program is detailed in Table 5-1.

Table 5- 1: Proposed fluid sampling program

Sampling Section	Sampling Formation	Depth Intervals, ft	Volumes
Intermediate, openhole	Ojo Alamo	1,330-1,920	1L
	Kirtland	1,920-2,059	1L
	Fruitland	2,059-2,769	1L
	Pictured Cliffs Ss.	2,769-2,904	1L
	Cliffhouse	4,334-4,515	1L
	Point Lookout	5,045-5,305	1L
Production, openhole	Dakota	7,185-7,340	1L
	Salt Wash	7,650-7,920	1L
	Bluff	7,920-8,090	1L
	Entrada	8,192-8,306	1L

6 Proposed Pre-Operational In-Situ Testing

The UIC-VI Well Site Characterization Guidance, Construction Guidance, and other guidance require measurement of pore pressure and in situ stress in both confining and reservoir zones: [40 CFR 146.82(a)(3)(iv), 40 CFR 146.88(a)]. Step rate testing is a common method for determining fracture pressure. The guidance eliminates standard DFIT tests and step rate tests, as surface pressure measurements need a friction correction—measurement of the minimum horizontal stress at appropriate accuracy and for the lithologic variability necessitates downhole measurements.

Table 6-1 presents the geologic units, their estimated depth intervals, and where mini-frac, pore pressure, or other testing are recommended. In addition, relatively long-term well testing is recommended. The Site Characterization guidance states the following: "EPA encourages owners or operators to use data from field testing, well logging, and laboratory analyses of cores to estimate intrinsic (absolute) permeability… Well tests measure a much greater area than core samples. As such, well testing tends to provide composite representations of localized variability."

Thus, for the primary target Entrada Formation reservoir, in addition to the permeability measurement obtained during the mini-frac testing, we propose relatively long-term injection testing for pressure and/or rate transient testing to infer large-scale permeability and leaky overlying aquitard/confining unit behavior if present. Such longer-term testing would not be done with a downhole tool in an open wellbore, but through perforation in casing, but we still recommended downhole pressure gauges.

Note that the exact number of mini-frac tests and their location will be finalized after logging of the characterization well.

Table 6-1: Recommended in-situ testing at the characterization well

Description	Geologic Unit	Depth Interval (ft)*	Testing Types
Secondary Seal	Lower Mancos Shale	6632 - 7073	Pore Pressure, Mini-frac
Secondary Seal	Morrison Fm., Brushy Basin Mbr., Shale	7340 - 7650	Pore Pressure, Mini-frac
Potential permeable lithology	Morrison Fm., Brushy Basin Mbr., Sand	7340 - 7650	Pore Pressure, Mini-frac
Potential sealing lithology	Morrison Fm., Salt Wash Mbr., Shale	7650 - 7920	Pore Pressure, Mini-frac
Secondary Reservoir	Morrison Fm., Salt Wash Mbr., Sand	7650 - 7920	Pore Pressure, Mini-frac
Secondary Reservoir	Bluff Fm.	7920 - 8090	Pore Pressure, Mini-frac
Primary Seal	Summerville Fm.	8090 - 8173	Pore Pressure, Mini-frac
Primary Seal	Todilto Fm.	8173 - 8192	Pore Pressure, Mini-frac
Primary Reservoir	Entrada Fm.	8192 - 8306	Pore Pressure, Mini-frac, Long-term injection (PTA/RTA)
Underlying Seal	Carmel Fm.	8306 - 8528	Pore Pressure, Mini-frac
*Estimated top and bottom depth of the given geologic unit. See the main text for guidance on testing depths.			

3. Statement of Project Objectives

San Juan Basin CarbonSAFE Phase III: Ensuring Safe Subsurface Storage of CO_2 in Saline Reservoirs

A. OBJECTIVES

The overall objective of this project is to perform a comprehensive commercial-scale site characterization of a storage complex located in northwest New Mexico to accelerate the deployment of integrated carbon capture and storage (CCS) technology at the San Juan Generating Station (SJGS), a nearby 847 MW coal-fired electricity generation. The data collected by the characterization and environmental analysis will be used to prepare, submit and attain a Class VI permit (for construction) to inject and store at minimum 50 million tonnes of CO_2 at the site. The project team will acquire new field data, and integrate new and legacy information to develop comprehensive site specific data sets that will be used as inputs for the preparation process of a UIC Class VI permit that will be submitted for approval. Data will be incorporated into simulation models to assess storage potential, CO_2 behavior, seal integrity and risk of induced seismicity. An Environmental Information Volume (EIV) will be completed to assess any NEPA-related issues for the chosen capture, transport and storage site. The project team will continue existing outreach programs to educate the public on the usefulness of the integrated CCS project within the region.

B. SCOPE OF WORK

The project objectives will be achieved through the execution of nine tasks. Task 1, Project Management and Planning, will span the duration of the project and ensure that all subsequent tasks and activities are completed according to specified timelines. Task 2 includes work elements supporting NEPA compliance for this project, submission of an EIV (within six months), and Preparation and Submission of NEPA Documentation for potential future construction and operation. Task 3 Site Characterization includes evaluation of existing data and collection of requisite additional data (including drilling a stratigraphic characterization well and possible acquisition of new geophysical survey) to assist in detailed characterization of the selected storage complex within the San Juan Basin. Task 4 includes the analyses of site characterization data as well as logs, cores and fluid samples from the stratigraphic well. Task 5 will utilize the data collected in Tasks 3.0 and 4.0 to develop an updated geologic model and advanced dynamic models. The models will be used to assess the potential of the storage reservoir and sealing caprock. Task 6, UIC Class Permit Application, includes the activities that support the preparation and submittal of the UIC class VI permit. Task 7, CO_2 source viability, includes the development of an integrated assessment model for CCS implementation in the San Juan Basin and greater Four Corners Region. Task 8, outreach, spans the duration of the project and includes the development and implementation of an outreach plan that informs stakeholders and the community facilitating acceptance of the safety and utility of the CCS project. Task 9, collaboration with other DOE-sponsored projects, spans the duration of the project and includes working with other CCS/CCUS projects to accelerate the implementation of commercial CCS projects as well as supporting DOE's Machine learning initiative.

C. TASKS TO BE PERFORMED

Task 1.0 – Project Management and Planning

Subtask 1.1 – Project Management Plan

The Recipient shall manage and direct the project in accordance with a Project Management Plan to meet all technical, schedule and budget objectives and requirements. The Recipient will coordinate activities in order to effectively accomplish the work. The Recipient will ensure that project plans, results, and decisions are appropriately documented and project reporting and briefing requirements are satisfied.
The Recipient shall update the Project Management Plan 30 days after award and as necessary throughout the project to accurately reflect the current status of the project. Examples of when it may be appropriate to

update the Project Management Plan include: (a) project management policy and procedural changes; (b) changes to the technical, cost, and/or schedule baseline for the project; (c) significant changes in scope, methods, or approaches; or (d) as otherwise required to ensure that the plan is the appropriate governing document for the work required to accomplish the project objectives.

Management of project risks will occur in accordance with the risk management methodology delineated in the Project Management Plan in order to identify, assess, monitor and mitigate technical uncertainties as well as schedule, budgetary and environmental risks associated with all aspects of the project. The results and status of the risk management process will be presented during project reviews and in quarterly progress reports with emphasis placed on the medium- and high-risk items."

Subtask 1.2 – Data Management Plan

The Recipient shall update the Data Management Plan (DMP) as necessary and maintain throughout the project. Relevant data will be appropriately stored and submitted to the DOE's Energy Data eXchange.

Subtask 1.3 – Advisory Board

An advisory board will be developed from both the CCS coordination team as well as from external sources. The advisory board will be developed from multiple sectors, including industry, business, technical, regulatory, and the community. The Governance structure, roles and responsibilities, project feedback mechanisms, and recommendation strategies will be instituted. The external advisory board will hold periodic meetings in addition to conference calls to discuss project technical issues and path forward.

Task 2.0 – National Environmental Protection Act (NEPA)

The recipient will perform all work elements required to obtain a NEPA determination for the proposed site(s) and support the required NEPA review process.

Subtask 2.1 – Preparation and Submission of NEPA Documentation for Site Characterization and CO2 Capture Assessment

The recipient will provide information required to obtain a NEPA determination for this project, including the provision of environmental questionnaires for all project locations and activities.

Subtask 2.2 - Preparation and Submission of an Environmental Information Volume (EIV) ***for potential future construction and operation***

The recipient will complete an EIV to assess any NEPA-related issues at the chosen site(s). The purpose of the EIV, http://netl.doe.gov/File%20Library/Business/forms/451_1-1-6.pdf, is to initiate analysis of the chosen capture, transportation and storage site(s) from a NEPA perspective. The completed EIV will provide all initial environmental data and details about the future proposed actions to take place through the post injection site care period.

Subtask 2.3 - Preparation and Submission of NEPA Documentation ***for potential future construction and operation***

Following NEPA's review of the EIV, the recipient will work on the documentation required for the probable NEPA class of action (Categorical Exclusions, Environmental Assessment or Environmental Impact Statement). The recipient, in conjunction with the third party, will provide all recommended documentation and support to NETL's NEPA department until a final NEPA document with a Record of Decision or Finding of No Significant Impact is completed.

Task 3.0 – Site Characterization

The recipient shall collect and evaluate data necessary to perform a thorough characterization of subsurface and surface elements of the storage complex relevant to the UIC process. Data includes but is not limited to groundwater, hydrogeology, geology, structural framework, geomechanical and petrophysical data.

Subtask 3.1 Evaluate available data

Subtask 3.1.1 Evaluate USDW Data

To establish a geochemical baseline, the recipient shall continue to collect and evaluate information gathered on known and potential USDW aquifers. The Ojo Alamo Sandstone is believed to be the deepest USDW. However, the water quality of deeper hydrocarbon zones in the nearest wells have been inconsistently sampled; there have been reports of marginal (just slightly above 10,000 ppm TDS) waters in nearby wells in these hydrocarbon zones. The recipient will sample and analyze known USDWs (alluvium, Nacimiento Fm. and Ojo Alamo Fm.) and hydrocarbon zones (Kirtland/Fruitland System, Gallup Sandstone, and Dakota Sandstone) on a quarterly basis from the nearest available wells. The nearest wells for each formation fall along a gradual, regional chemical gradient that is structurally controlled and are closer than the historically available data.

3.1.2 Evaluate Available Local and Regional Seal Data

The recipient shall evaluate local and regional seal data to assess the potential for new fracture formation or reactivation of existing fractures and faults due to changes in subsurface stress during CO_2 injection. Variability in sealing lithologies and across seal-reservoir interfaces on local and regional scales will be evaluated using available wireline logs following the methods of Petrie et al. (2012).

Subtask 3.1.3 Evaluate available seismic data

The recipient shall evaluate available 2D/3D seismic data suitability for site characterization as well as for potential use as a baseline monitoring survey. If available seismic data is not suitable then new seismic data will be acquired (subtask 3.3).

Subtask 3.2 Field work/mapping

Outcrop studies have limited applicability as the storage system formations only crop out at the margins of the San Juan Basin (~65 miles away from the site of interest). An assessment will be made to determine if any outcrops would inform length-scales of heterogeneity of sealing and reservoir lithologies and natural fracturing styles. If so, outcrop studies will assess spatial variability of key properties.

Go No Go Decision Point: After the recipient evaluates the available surface seismic (subtask 3.1.2) it will notify NETL whether it will proceed with the acquisition of new 3D surface seismic (subtask 3.3.1). If available surface seismic is adequate the Recipient will document the impact on the project budget and provide to NETL. The recipient will document the surface seismic strategy prior and notify NETL prior to proceeding. ***The recipient shall not proceed with any surface seismic acquisition without written authority of DOE's Contracting Officer.***

Subtask 3.3 New Seismic Work

Should commercially available 3D seismic data be deemed unsuitable for use (subtask 3.1.3) the recipient will conduct an approximately 25mi^2 optimized 3D surface seismic survey to image the potential lateral extent of the CO_2 plume. A 3D Vertical Seismic Profile (VSP) survey centered on the stratigraphic well will be acquired. During the data processing phase the acquired VSP data will be integrated (co-processed) with legacy or newly acquired surface seismic data. This allows for improved velocity control and reduced uncertainty in interpretation.

Subtask 3.3.1 Acquisition

A detailed Survey Evaluation and Design (SED) will be conducted for new 3D surface seismic (if necessary) and the 3D-VSP surveys. Surface coverage will be planned to produce a full imaged subsurface area encompassing the predicted lateral extent of the CO_2 plume with maximum subsurface coverage at the target reservoir(s).

Subtask 3.3.2 Processing

Fidelity of legacy imaged data (migration stack sections) and pre-stack gathers will be evaluated by examining the soundness of the processing sequence and algorithms applied during data processing. Reprocessing of legacy data using the latest processing algorithms might be required. In the case of newly acquired surface seismic, the latest processing techniques will be applied. Petrophysical logs will be used to perform well-tie to seismic to reduce uncertainty in structural interpretation. Post imaging (post or/and pre-stack inversion) will generate seismic inversion attributes used to derive porosity, lithology information and fluid discrimination.

Subtask 3.4 Stratigraphic Well Drilling

A stratigraphic test well will be drilled in the area of interest to an approximate depth of 9500'. The principal zones of interest for characterization are the Morrison and Entrada formation. Data to be gathered from the wellbore will include open hole logs, core from the target reservoir intervals and seals, fluid samples from sandstone formations and known USDW's. Diagnostic pressure testing and long-term injection tests will be performed in the perforated target intervals. The UIC Program Class VI well site characterization guidance documents will be followed ensuring that the data collected and analyzed meet all requirements to assist in the permit application process.

Subtask 3.4.1 Location identification

The location for the stratigraphic test well will be chosen based on factors such as depth and thickness of reservoir and seal formation(s), structural features and fault locations, as well as issues of land ownership, surface accessibility and use, cost factors, and expected plume migration based on current simulation and optimization under uncertainty results.

Subtask 3.4.2 Design

Well design will be based on available reservoir information, requisite data needs, and permitting requirements from the regulatory entities. The design will cover the well casing design, mud program, cementing, coring, openhole logging, perforation design, fluid sampling, and injection testing parameters that are required for a UIC VI monitoring well. Well construction requirements will be met as outlined in 40 CFR 146.86.

Subtask 3.4.3 Permitting

The project team will work with the New Mexico Oil and Gas Division (NMOCD) and NM State Lands office to ensure that all requirements are met for leasing and permitting of the stratigraphic well.

Subtask 3.4.4 Drilling

A vertical stratigraphic well will be drilled. Drilling operations will be conducted per NMOCD rules as outlined in 19.15.16 NMAC. Intermediate hole well logs, coring and production hole logs will be additional operations performed during drilling operations as outlined in the following subtasks.

Subtask 3.4.5 Coring (seals and reservoirs)

A mud log and geological sample log will be maintained from below surfacing casing to total depth. Correlation of formations, members and key beds will be verified while drilling. Representative whole core samples will be collected from seal and reservoir units, including the following: Morrison Formation, Entrada Sandstone, Bluff Sandstone, Summerville Formation, Todilto Limestone, and the Chinle Formation. If there are difficulties in collecting whole core, sidewall coring is an option for the seals and reservoirs.

To support lithologic and flow pattern characterization of USDWs and any interbedded low permeability zones in the USDWs, sidewall cores may be collected and/or core and cuttings at the New Mexico Subsurface Data, Core & Cuttings Libraries may be examined. Sidewall coring may depend on formation competency and UIC Class VI requirements. Potential USDWs include: Ojo Alamo Formation, Nacimiento Formation, Fruitland Formation, Kirtland Formation (i.e., Farmington Sandstone member), Gallup Sandstone, and Dakota Formation.

Subtask 3.4.6 Open Hole and Cased Hole Well Logging

Baseline characterization logs will include a standard quad-combo (resistivity, density, neutron, dipole sonic, and associated correlation logs) and wellbore images. In addition, advanced specialized logs may be acquired over the storage interval including spectral gamma ray, nuclear spectroscopy, nuclear magnetic resonance, and geomechanical related measurements. Basic and advanced cement and casing evaluation logs will be run to assess casing and wellbore integrity.

Subtask 3.4.7 Pressure and Temperature Measurements

The characterization well could potentially be repurposed for long term monitoring; therefore, feasibility and risk of installing Distributed Temperature Sensing (DTS) and/or Distributed Acoustic Sensing (DAS) fiber cable(s), either behind production casing or along the tubing, will be assessed. Installation of downhole pressure and temperature gauges (permanent or memory) will be also explored.

Subtask 3.4.8 Fluid sampling

Fluid samples will be taken from target reservoirs, the Morrison Formation and/or Entrada Sandstone formation, and analyzed (subtask 4.2).

Subtask 3.4.9 Perforating

The stratigraphic well will be perforated at appropriate intervals based on open hole logs and core data for the injection tests to be performed in subtask 3.4.10.

Subtask 3.4.10 Well Testing

Perforation intervals (subtask 3.4.9) will undergo diagnostic injection testing to obtain fracture initiation pressure, initial shut-in pressure, fracture closure pressure, and if pressure fall-off data is sufficient: pore pressure and permeability of the target formation. The proposed injection formations will undergo long term injection tests that will support preparation of the Class VI permit as required in 40 CFR 146.87. The testing will include several days of injection and subsequent pressure fall-off. The data will be recorded and analyzed by pressure transient methods. The outcome of the testing includes estimates of CO_2 injectivity, storage capacity, and the storage efficiency factor (subtask 4.8).

Subtask 3.5 Offset Well Testing

In order to obtain a second dynamic measurement of injection zone properties, well testing will be conducted in offset acid gas injection well Pathfinder AGI #1 located approximately 17 mi. southeast from the injection site along the direction of structural strike. The existence of historical injection rate and pressure data in this well makes it a valuable analog for analysis of long-term injection into the Entrada formation. Operations will include injection testing, pressure monitoring surveys, and completion of pressure fall-off monitoring. Injection test operational planning assumes utilization of brine as the injectate. Utilization of CO_2 as the injectate will also be investigated.

Task 4.0 – Reservoir and Caprock Characterization

Task 4.0 includes characterization and testing efforts to support the UIC Program Class VI permitting following the Class VI guidance documents on characterization and well testing and monitoring. Subtasks include site characterization with well log data, fluid chemistry baselines, core analysis for petrophysical, multiphase flow and geomechanical properties, and testing to support plume monitoring using seismic methods. The results will determine the adequacy of storage and injectivity and assist in building predictive models of fluid behavior, plume migration, and caprock integrity.

The project team will complete necessary characterization requirements to support the successful submission of the UIC Class IV well permit application by the end of Budget Period 1. The laboratory and analysis subtasks of Task 4.0 will be completed in Budget Period 2 in order to: 1) obtain additional data that narrow uncertainty bounds on CO_2 injectivity, storage capacity, storage efficiency factors, and caprock sealing behavior to improve implementation and operations of the full-scale storage complex; and 2) leave flexibility for further testing as needed to address specific feedback from the EPA review committee during Budget Period 2. In the permit and if appropriate, the project team will notify the permitting agency that the project timeline has the flexibility to perform additional testing to address potential characterization concerns.

Subtask 4.1 Well Log Analysis

Newly acquired logs will be analyzed in detail to provide data inputs to geologic and simulation models. Analysis will include stratigraphic correlation, petrophysical and geomechanical attributes.

Subtask 4.2 Fluid Analysis

Fluid samples obtained in Task 3.4.8 will be analyzed for major ions, pH, alkalinity, total organic carbon (TOC), trace metals, and stable water isotopes. The analyses will be used for geochemical experiments and modeling efforts.

Subtask 4.3 Core Description and Analysis

Cores will be analyzed and described. Analyses will include assessment of mineralogy, lithofacies, heterogeneity, petrophysical properties, and inventory and characterization of fractures. Preliminary assessment will be performed before slabbing or plugging to minimize damage from those activities. Fracture types, relative orientation, mineralization, and apertures will be measured. Following initial assessment, core will be slabbed and described in detail. Stratigraphic units will be identified and lithofacies will be described. Multiple (~50 to 75 depending on heterogeneity) core plugs will be taken from the core and evaluated for porosity, single phase (gas) permeability, total organic content, and residual water content. At least three samples per primary seal and reservoir will be preserved in “seal-peel”.

Subtask 4.4 Microscale Analysis

Petrographic thin section analysis and electron microscopy will assess mineralogy and diagenetic relationships of the lithofacies of the primary and secondary seals. These data link lithologic and diagenetic features to the mercury intrusion capillary pressure measurements and material response measured by lab tests. Supporting mineralogical compositional techniques include backscatter scanning electron microscopy (BSEM), scanning electron microscopy (SEM), and X-Ray diffraction (XRD). Reservoir pore structure will be measured with X-ray computed tomography (XRCT). Primary seal pore-structure and pore-lining phases will be measured in 3D using focused ion beam-scanning electron microscopy.

Subtask 4.5 Reservoir Multiphase Flow Properties: Experiments and Analysis

Multi-phase relative permeability and capillary pressure will be estimated using pairs of brine and CO_2 at different flow rates and operating conditions. Mercury injection capillary pressure measurements will be performed on collocated samples. Interpretation of the multiphase flow data will be supported by petrography and XRCT.

Subtask 4.6 Mechanical Testing and Caprock Integrity

This subtask includes laboratory testing necessary to estimate static, seismic and dynamic elastic mechanical properties, compression and shear velocities, yield and failure envelopes at vertical, horizontal and 45 degrees to define a mechano-stratigraphy for weak and strong facies and to correlate to wireline logs.

Subtask 4.6.1 Mechanical Testing of Reservoir, Potential Seal and Seal Lithologies

Tests on reservoir cores will include measurement of tensile strength, unconfined compressive strength, triaxial compressive strength, and multi-stage compression behavior to obtain yield and failure envelopes, stress-dependent static elastic moduli, and mechanical anisotropy. The fracture toughness and subcritical fracture index of the seal(s) will be measured at reservoir conditions with and without CO_2.

Subtask 4.6.2 Caprock Integrity

Analysis on seal rocks will include: mercury capillary pressure measurements; thin sections of fractures and whole rock; specialized petrography including focused ion beam-scanning electron microscopy; porosity and permeability; and fracture toughness and subcritical fracture indices.

Subtask 4.6.3 Ultra-Sonic Core Measurements Under Stress and CO_2 Saturations

During injection, effective stresses will decrease, and fluid saturations will be modified, requiring updated velocities as a function of effective stress and CO_2 saturation. During a subset of the relative permeability experiments, ultrasonic velocities will be simultaneously measured for the reservoir rocks at a number of different effective stresses and CO_2 saturations using a pulse-receiver technique at simulated reservoir conditions and compared to Biot-Gassmann theory.

Subtask 4.6.4 Direct estimate of ultrasonic to seismic velocities, and static to dynamic moduli

In order to link ultrasonic, slowness geophysical logs and seismic data, the dynamic moduli at seismic (e.g., 1 - 150 Hz) and ultrasonic (>100 kHz) frequencies will be determined for relevant core intervals at variable CO_2 saturations and reservoir conditions. This is necessary to aid in delineating plume extent using seismic methods and linking seismic stratigraphy to ultrasonic measurements.

Subtask 4.7 Data Synthesis and Upscaling

The descriptive and quantitative information of core analyses will be provided to the reservoir modelers. Upscaling of elastic moduli will be estimated from descriptive work at multiple scales, electrical conductivity and acoustic velocity measurements, and seismic velocity measurements. Relative permeability, intrusion pressures, and wettability will define hydrologic flow units; the flow units will form a basic element of the reservoir modeling. Petrography, core analysis and field description will define the nature of porosity and range of controls on permeability. Rock strength will be associated with flow units in the reservoir. For the seals, mechanical and hydrologic stratigraphic units will be defined and simplified for the simulations. Measured borehole stresses and estimated Mohr envelopes will be used to estimate how close to failure the reservoir is.

Subtask 4.8 Well Test Analysis

Well test data collected as part of subtask 3.4.10 will be analyzed using appropriate techniques for the various objectives. Step rate test or formation dynamic test tool data will be evaluated to establish fracture gradient. Injection/fall-off test data will be analyzed for skin factor, static injection zone pressure, transmissivity, and to determine the existence of nearby faults, fractures, or barriers to flow**.** The outcome from the well tests will assist in the computation of storage efficiency factor (subtask 5.1.3).

Subtask 4.9 Offset Well Test Analysis

In addition to being an additional datapoint for reservoir information derived from the well test itself, the large body of historical injection rate and pressure data available in the offset well makes it a valuable analog for modeling of longer term (Entrada) injection zone response than can be deduced from injection tests alone. In addition to routine well test analysis as will be performed on the stratigraphic test well, a 3D model will be built which encompasses both wells and this model will be history matched to historical acid gas injection rates/pressures**.** This modeling will help to constrain estimates of uncertain reservoir properties and sense boundaries outside the area of investigation of the stratigraphic well test and available well data.

Task 5.0 – Geologic Modeling and Simulation

The development of an integrated numeric geologic model (static) provides a practical means by which to incorporate the numerous characterization efforts in a meaningful way. A high quality static geological model becomes the cornerstone for transient hydrodynamic, reactive transport, and geomechanical process modeling. These static and dynamic process models will be utilized throughout the project for tasks ranging from data acquisition planning, site development including CO2 injection scheduling, and risk assessment.

Subtask 5.1 Static Modeling

The preliminary geologic model will be updated using newly acquired data. The updated geologic model will cover the storage complex and surrounding area, and will include heterogeneity, flow barriers and/or pathways identified from data collected in Tasks 3 and 4.

Subtask 5.1.1 Geologic framework

Structural and stratigraphic features interpreted from 3D seismic and well logs will provide the framework for geologic model. A 3D velocity model will be generated through integration of seismic-well ties (where suitable data is available), geologic well picks, and seismic time interpretations. Any seismically resolvable faults/fractures within the reservoir will be mapped out and included into the modeling process. Depth converted seismic stratigraphic and structural interpretations will be used to define the framework of a geocellular grid. Should significant numbers of natural fractures be observed in image logs the natural fracture system(s) will be developed using Discrete Feature Network (DFN) modeling techniques.

Subtask 5.1.2 3D hydrodynamic and mechanical model

Model formation properties will be updated with new well log and seismic data, interpolated using a combination of Bayesian and stochastic methods. Hydraulic and mechanical facies types will be identified through machine learning evaluation of petrographic and mechanical log and core data.

Subtask 5.1.3 CO_2 Storage Estimation

This subtask will utilize static models established in subtask 5.1.1 to estimate the CO_2 storage capacity distributions in the area of interest using a variety of approaches. Methods may include: parametric stochastic estimation approach using Monte Carlo analysis to estimate the p90, p50 and p10 CO_2 storage capacity distributions; NETL CO_2 injection screening tool (CO2-SCREEN) will be used to assess the CO_2 sequestration potential of the area in a stochastic manner; or use of analytical models to approximate CO_2 storage volume.

Subtask 5.2 Storage Complex Modeling

A series of advanced modeling techniques will be used to develop models for storage optimization, monitoring, prediction of reservoir behavior and caprock integrity. The modeling efforts will be used to ascertain the long-term storage potential within the study complex.

Subtask 5.2.1 Hydrodynamic Simulation modeling

An advanced hydrodynamic numerical reservoir simulation model will be employed to simulate the fluid flow dynamics of the CO_2-brine system and analyze reservoir response due to large scale CO_2 injection activities using CMG and Eclipse. The hydrodynamic simulation model establishes a useful base case for storage strategy optimization and long-term CO_2 monitoring.

Subtask 5.2.2 Relative Permeability calibration and modeling

The laboratory relative permeability and capillary pressure curves measured in Task 4.5 will have to be calibrated using existing correlations, such as the Corey's Curve or van Genuchten formula, before they can be used in the planned numerical simulations that will be conducted under Task 5.2. With a number of different methods for calibration of the laboratory data, there is a degree of uncertainty imparted on the simulation model depending on which methods and parameters are used. This can have an effect on the AoR and overall storage capacity.

We plan to capture this range of uncertainty by using an ensemble of different calibration methods to elucidate the effect on the total storage capacity and AOR. We will create a range of different relative permeability and capillary pressure curves from the laboratory relative permeability and capillary pressure data. The suite of curves will be tested with the simulation model to ascertain their long-term effect on storage within the selected storage complex.

Subtask 5.2.3 Rock Physics Modeling

Geophysical logs, core, reservoir fluid samples, and estimated CO_2 injectant properties will be integrated to create rock physics models for injection and sealing formations in the AoR. These studies support development of plume and pressure front monitoring plans. Detection limits and parameter uncertainty will be investigated for seismic and potential field monitoring techniques using various field geometries such as surface, single well, and cross well.

Subtask 5.2.4 Geomechanical Modeling

The static mechanical earth property model developed in subtasks 5.1.1 and 5.1.2 will be integrated with the simulation model developed in subtask 5.2.1 to perform coupled hydro-mechanical modeling of stress/strain behaviors in the injection and caprock zones during CO_2 injection. The calibrated coupled model will be used to investigate caprock integrity and wellbore stability.

Subtask 5.2.5 Geochemical Modeling

Reactive transport modeling will be performed to study the changes to water chemistry, mineralogy, reservoir porosity (trapping capacity), sealing performance, and any potential impacts on USDW quality (especially toxic trace metals) that can be expected during the lifetime of the project and long-term storage. Fluid-rock interaction modeling will be performed within target injection zones. Salt precipitation modeling will be performed to study potential deposition as a result of injection. Reservoir simulators TOUGHREACT & STOMP will be employed to characterize the effect of long-term geochemical reactions on storage within the storage complex.

Subtask 5.2.6 Caprock Integrity Modeling

The modeling results from subtasks 5.2.1- 5.2.5 will be used to model the impact of CO_2 injection on the caprocks identified as primary and secondary seals. Scenario modeling will be performed to investigate uncertainty in key parameters impacting CO_2 containment such as caprock thickness, mechanical properties, capillary properties, and geochemistry.

Subtask 5.2.7 Forecasting CO_2 Storage Scenarios

The base simulation case structured in Subtask 5.2.1 will be used to investigate different injection scenarios that vary the number of injection and production wells, well operational designs, well spacing designs, etc., all honoring the constraint that stabilization pressure after wells are shut-in should not exceed the initial reservoir pressure to secure long-term storage. Information gained from preceding tasks (5.2.2, 5.2.3, 5.2.4, 5.2.5, 5.2.6) will be included in the forecasting scenarios.

Subtask 5.2.8 Storage Optimization Modeling

Optimization modeling will identify the best CO_2 injection protocol(s) to achieve the injection volume using a minimum number of injection wells and producing a minimum volume of brine. Machine-learning based proxy models may be developed to reduce the computational overhead optimization process.

Subtask 5.2.9 Area of Review (AoR) Modeling

The compositional simulation model developed in subtask 5.2.4 will be used to re-evaluate preliminary AoR estimates. Free and trapped phase CO_2 distributions will be computed until such time that the plume stabilizes. The maximum aerial extent of the free phase CO_2 plume will be established. Reservoir pressure increase above pre-injection conditions will be computed for all simulation time steps and the threshold pressure front re-evaluated. Based on these results the AoR will be updated. These data will also be used to establish the PISC period.

Subtask 5.3 Risk Analysis and Mitigation

We will conduct risk assessment activities throughout the project lifecycle. Site-specific features, events, and processes (FEPs) will be identified and evaluated, and a variety of NRAP tools employed to assess risk and develop management and mitigation plans as well as to design strategic monitoring plans.

Subtask 5.3.1 Risk Assessment

A risk registry will be compiled which will include risks specific to project execution and updated at regular intervals. Probability distribution functions (PDFs) will be developed for the identified FEPs, utilizing Monte Carlo approaches, response surface methodologies, and other methods. Our overall risk assessment will include evaluation of leakage as well as induced seismicity risks.

Subtask 5.3.2 NRAP

Multiple NRAP tools will be used to (1) aid in estimation and delineation of AoR and (2) assess subsurface leakage and induced seismicity risks. Applications of selected NRAP tools will help inform the characterization efforts in order to reduce the knowledge uncertainties and their impact on risks and to assess the effectiveness of various risk mitigation strategies. The REV tool will be applied to estimate pressure and saturation-based AoRs using simulation results from Task 5.3.1. These AoRs will be compared against risk-based AoRs computed using NRAP-Open-IAM. The NRAP-Open-IAM tool will be used to estimate potential CO_2 and brine leakage risks considering any leakage pathways. The DREAM tool will be employed to help develop optimal monitoring plans. Induced seismicity risks will be assessed using NRAP's STSF and GMPIS tools.

Task 6.0 – Underground Injection Control (UIC) Class VI Permit Application

The UIC Class VI well permit application(s), one for each proposed Class VI well, will meet all requirements of 40 CFR 146.82 and those parts referenced therein. To this end, the team will prepare a Class VI requirement matrix, identifying all critical technical and non-technical components (Subtasks 6.1 to 6.9) necessary for a successful Class VI permit application. The lead for Task 6 will work with the other project task teams throughout BP1 to ensure Class VI specifications and guidelines are adhered to and the necessary permit components are assembled.

Subtask 6.1 Site Characterization

As required by 40 CFR 146.82 (a) (2) through (7), the team will submit with the permit application information from within the area of review indicating the project meets the minimum siting criteria in 40 CFR 146.83. This information will include characterization of the injection zone(s) and confining zone(s) for: geologic structure, hydrogeology, vertical and lateral extent, mineralogy, geochemistry, porosity, permeability, and geomechanical properties. Proposed operating data will also be submitted including: average and maximum daily rate and volume and/or mass and total anticipated volume and/or mass of the CO_2 stream; average and maximum injection pressure; source of CO_2, and an analysis of the chemical and physical characteristics of the CO_2 stream.

Subtask 6.2 Area of Review and Corrective Action Plan

As required by 40 CFR 146.84 (b) and to fulfill the requirements of 40 CFR 146.82 (a) (2) and (4), we will prepare and submit with the permit application an Area of Review and Corrective Action Plan (plan) consistent with 40 CFR 146.84. The plan will include the method for delineating the area of review, a description of monitoring, and operational conditions that would warrant a reevaluation of the area of review prior to normally scheduled reevaluations. The plan will discuss the identification and evaluation, using approved methods, of all artificial penetrations within the area of review completed into the confining zone(s) and discuss any corrective action to be performed on artificial penetrations determined to need corrective action. Development of the plan will be informed by Section 2 of EPA's Class VI Project Plan Development Guidance and Class VI Well Area of Review Evaluation and Corrective Action Guidance.

Subtask 6.3 Well Construction Plan

As required by 40 CFR 146.82 (a) (12), the team will prepare and submit with the permit application a Well Construction Plan, consistent with the requirements in 40 CFR 146.86, which will ensure that the Class VI well(s) will be constructed to prevent movement of fluids into or between USDWs or into any unauthorized zone; to allow the use of appropriate testing devices and workover tools; and to allow continuous monitoring of the annulus space between the injection tubing and long string casing. As required by 40 CFR 146.82 (a) (8), we will prepare and submit with the permit application a proposed pre-operation well and formation testing plan to obtain information on the well as it is drilled and built and to obtain an analysis of the chemical and physical characteristics of the injection zone(s) and confining zone(s) and that meets the requirements at 40 CFR 146.87. Development of the plan will be informed by EPA's Class VI Well Construction Guidance and the Class VI Testing and Monitoring Guidance.

Subtask 6.4 Proposed Well Operation Plan

As required by 40 CFR 146.82 (a) (10), the team will prepare and submit with the permit application a Well Operation Plan consistent with the requirements of 40 CFR 146.88. The plan will require that injection pressure does not exceed 90% of the injection zone fracture pressure except during stimulation; prohibit the injection between casing and formation; require the annular space between tubing and casing be filled with non-corrosive fluid at pressures exceeding the operating pressure; require maintenance of mechanical integrity at all times; and require the use of continuous monitoring devices. Development of the plan will be informed by Section 4 of EPA's Class VI Well Construction Guidance.

Subtask 6.5 Proposed Testing and Monitoring Plan

As required by 40 CFR 146.82 (a) (15), the team will prepare and submit with the permit application a Testing and Monitoring Plan consistent with the requirements in 40 CFR 146.88-90. The required elements of the Testing and Monitoring Plan, will include: injecting fluid analysis, monitoring the injection operation, corrosion monitoring, monitoring of geochemical changes in the subsurface, mechanical integrity tests (MITs), pressure fall-off testing, tracking the carbon dioxide plume and area of elevated pressure, surface air and/or soil gas monitoring for carbon dioxide fluctuations (at the discretion of the UIC Program Director), a quality assurance and surveillance plan for all testing and monitoring requirements, and any additional tests determined by the UIC Program Director to be necessary to ensure protection of USDWs from endangerment. Development of the plan and sub-plans will be informed by Section 3 of EPA's Class VI Well Project Plan Development Guidance and the Class VI Well Testing and Monitoring Guidance.

Subtask 6.6 Proposed Injection Well Plugging Plan

As required by 40 CFR 146.82 (a) and 40 CFR 146.92(b). the team will prepare and submit with the permit application a plugging and abandonment plan consistent with 40 CFR 146.92 and acceptable to the UIC Director. Development of the plan will be informed by Section 4 of EPA's Class VI Well Project Plan Development Guidance and Section 2 of the Class VI Well Plugging, Post-Injection Site Care, and Site Closure Guidance.

Subtask 6.7 Proposed Post-Injection Site Care and Site Closure Plan

As required by 40 CFR 146.82 (a) (17) and 40 CFR 146.93 (a) (1), the team will prepare and submit with the permit application post-injection site care and site closure plan consistent with 40 CFR 146.93. Development of the plan will be informed by Section 5 of EPA's Class VI Well Project Plan Development Guidance and Section 3 of the Class VI Well Plugging, Post-Injection Site Care, and Site Closure Guidance.

Subtask 6.8 Emergency and Remedial Response Plan

As required by 40 CFR 146.82 (a) (19) and 40 CFR 146.94 (a), the team will prepare and submit with the permit application an emergency and remedial response plan describing the measures that will be taken in the event of adverse conditions at a GS project, such as a loss of the well's mechanical integrity, or if movement of injection or formation fluids caused an endangerment to a USDW. Development of the plan will be informed by Section 6 of EPA's Class VI Project Plan Development Guidance.

Subtask 6.9 Financial Responsibility

As required by 40 CFR146.85(a), the team will demonstrate and maintain financial responsibility for corrective action on wells in the Area of Review (AoR), injection well plugging, post-injection site care and site closure, and emergency and remedial response phases. Development of qualifying financial responsibility instruments meeting the requirements of 40 CFR146.85 will be informed by EPA's Class VI Financial Responsibility Guidance.

Subtask 6.10 Submission of Permit Application and Approval

Before the end of Budget Period 1 and prior to being given approval to proceed to Budget Period 2 of the project, we will submit to EPA Region 6 a UIC Class VI permit application for each proposed Class VI well. See FOA Part II (C) (ii). The team will work with the EPA office to secure approval for the drilling of Class VI well.

Task 7.0 – Assessment of CO_2 Technical Requirements

The work in this task will cover aspects related to capturing CO_2 at SJGS and transporting it to the proposed CO2 injection site.

Subtask 7.1 CO2 source viability

A technical evaluation of Enchant's FEED study will be performed to assess whether the proposed CO_2 capture technology at SJGS is technically viable and can reliably supply the amount of CO_2 necessary for the duration of geologic storage project.

Subtask 7.2 Evaluation of CO2 transport options and San Juan basin region opportunities

The recipient will perform a techno-economic analysis on the entire CCS project. The techno-economic analysis would include the engineering economic analysis for the capture unit, three identified pipeline routes to the cortex pipeline and storage site, and the storage site. The SimCCS model will also be used to characterize the primary route and the two alternative routes for transporting captured CO_2 to the proposed injection site. SimCCS can be used for very fine-scale pipeline routing decisions and to understand the economics of the chosen routes. In addition, the potential regional role of the San Juan basin as a CCS storage complex (i.e., storing CO_2 amounts significantly beyond the mandated minimum) will be examined. The higher-level analysis will utilize the SimCCS, SCO2T and other relevant modeling capabilities.

Task 8.0 – Stakeholder/Policymaker Outreach/Education and Engagement

Stakeholder outreach and engagement efforts will build on foundational work conducted prior to this project. An initial survey identified 48 stakeholders. The outreach activities will concentrate on developing appropriate messages and methods to address identified concerns and develop strategies to facilitate stakeholder acceptance.

Task 8.1 Outreach Plan Development

The recipient will develop an outreach plan that will guide the efforts of the outreach team, including communications between researchers and stakeholders. Important elements of the plan will include a) an assessment of which stakeholders are most critical to the project's success b) determinations of methods that would best reach those stakeholders c) creation of targeted messages addressing major concerns, either identified or potential that can be applied across a variety of occasions, media, and scenarios, and d) plans for deployment of outreach methods and message, based on results of a, b, and c. Multiple outreach methods including web sites, personal interactions, and various forms of conventional and social media will be considered. The outreach plan will identify and rank which methods will be used based on cost and likely impact. Another important element of the plan will be to create a hierarchy of responsibility within the project so that stakeholders have a point of contact, researchers have an understanding of how requests for information will be handled, and all project participants who will have contact with the public will have an agreed upon set of messages or talking points appropriate to the occasion. Finally, the outreach team must coordinate efforts with the industrial partner such that scientific integrity is maintained, sufficient and accurate information is provided to stakeholders, and consistent messaging exists between the project participants.

Task 8.2 Public Outreach

A project website will be developed and maintained. Although Enchant Energy LLC has already developed a website, the proposed project shall have a standalone web site to convey the scientific findings resulting from the work. Public information materials such as fact sheets, flyers, and brochures will be created and maintained.

Task 8.3 Identifying and Engaging Stakeholders

Follow-up to initial stakeholder identification and engagement shall be maintained and further developed. Activities include coordinating meetings, site visits, stakeholder surveys and continued community outreach. Specific outreach activities will be chosen based on results of stakeholder and message delivery assessments produced in the outreach plan.

Task 8.4 Participation in Regional and National Outreach Efforts

The outreach team will maintain a relationship with other carbon sequestration partnerships and participate with national outreach efforts as requested.

Task 8.5 Develop an Economic Assessment of the Area

The recipient will develop a cost benefit analysis incorporating social and environmental factors in order to develop a comprehensive assessment of the costs and benefits including market and non-market impacts, in the short and the long term. The intent is to provide communities and stakeholder groups with improved information with which to assess the project. This work will develop a framework with which to assess the costs and benefits; develop the plan of translating all impacts into comparable units in order to aggregate and/or compare outcomes; gather existing data from public sources, as well as drawing from other task areas. This data will be augmented with information and data from community participants and stakeholder groups, working with other Task 8 activities, as well as carrying out unique engagements with communities and stakeholders. Results will be shared with stakeholder and communities in order to provide information.

Task 9.0 – Coordination with other DOE Projects

The project will work with other CCS/CCUS projects to transfer detailed characterization, capture, transport, economic and regulatory data to regional/national/international stakeholders. In particular, the project team has significant overlap with the new *Regional Initiative to Accelerate CCUS Deployment* **(**DOE/NETL) project based in the western USA: the Carbon Utilization and Storage Partnership (CUSP). The data and experience from the San Juan Basin CarbonSAFE Phase III project will serve as a blueprint for other capture, transport and utilization/storage projects in the western US and beyond.

Additionally, the project will participate in DOE's Machine Learning Initiative as either a provider of relevant datasets, as available, for validating tools/methods developed through the initiative; or as a technical advisor on the development and feasible application of machine learning based tools/methods in a commercial scale setting. In addition, data acquired by the project will be provided to the NATCARB database as requested.

D. DELIVERABLES

The periodic and final reports shall be submitted in accordance with the Federal Assistance Reporting Checklist and the instructions accompanying the checklist. In addition to the reports specified in the "Federal Assistance Reporting Checklist", the Recipient must provide the following to the NETL Project Manager (identified in Block 15 of the Assistance Agreement as the Program Manager)**.**

A catalog of geologic materials/samples collected under the project must be developed and maintained throughout the project. Throughout the life of the project, the Recipient must provide to DOE physical access to available materials/samples upon request ensuring this request does not impede ongoing or planned investigations. If the Recipient does not wish to retain the materials/samples, then the Recipient must offer DOE the opportunity to obtain possession of available materials/samples before the materials/samples are disposed.

Data generated as a result of this project shall be submitted by the Recipient to NETL's Energy Data Xchange (EDX), https://edx.netl.doe.gov/ by the end of the project. The types of data and the rights and protections of such data will be determined during the award negotiation process at the discretion of the PI, Project Manager, and CS. The determination will be assisted by the initial submission of the DMP. The DMP should be updated to reflect the agreed upon data and timing to be submitted to EDX. Data includes but is not limited to: 1) datasets and files, 2) metadata, 3) software/tools, and 4) articles developed as part of this project.

Task / Subtask Number	Deliverable Title	Due Date
1.1	Project Management Plan	Update due 30 days after award. Revisions to the PMP shall be submitted as requested by the NETL Project Manager.
2.2	Environmental Information Volume	upon completion of Task 2.2
2.3	**Final NEPA document with a Record of Decision or Finding of No Significant Impact**	at end of Budget Period 2
3.3	Seismic Acquisition and processing Report	1 month after completing task 3.3
3.4	Stratigraphic well report	2 months after completion of Task 3.4
4	Reservoir and Caprock data analysis Report	2 months after completion of Task 4

6..9	Application for Underground Injection Control Class VI Permit to Construct	At the end of Budget Period 1
5.2	Complete Simulation modeling report	at end of Budget Period 2
5.3.2	NRAP Report	2 months after completion of Task 5.3.2
8.1	Outreach Plan	2 months after completion of Task 8.1
7	Assessment of CO2 Technical Requirements	at end of Budget Period 2
1	Catalog of Geologic Materials	**At the end of each project year.**

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E. BRIEFINGS/TECHNICAL PRESENTATIONS

The Recipient shall prepare detailed briefings for presentation to the NETL Project Manager at their facility located in Pittsburgh, PA, Morgantown, WV, Albany, OR, or via WebEx. The Recipient shall make a presentation to the NETL Project Manager at a project kick-off meeting held within ninety (90) days of the project start date. At a minimum, annual briefings shall also be given by the Recipient to explain the plans, progress, and results of the technical effort and a final project briefing at the close of the project shall also be given.

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CONDITIONS

Action 160174

CONDITIONS

Operator:	
NEW MEXICO INSTITUTE OF MINING & TECHNOLOGY 801 Leroy Pl Socorro, NM 87801	OGRID: 15847 Action Number: 160174 Action Type: [IM-SD] Well File Support Doc (ENG) (IM-AWF)

CONDITIONS

Created By	Condition	Condition Date
pgoetze	None	11/18/2022